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ABSTRACT

This study explores a learning model which suggests that a concept is acquired first through manipulation of concrete objects followed by transformation of the concrete objects into semi-concrete representations, followed by internalization of the concept through abstract representations. Microcomputer simulations of manipulative activities were used to determine how children differ in their use of science-process skills and concepts when using the simulations compared to using the concrete materials, or a combination of simulations and concrete materials. Subjects included 113 children distributed according to male and female, second- and fourth-grade level, and socio-cultural site. Criterion measures assessed the children's ability to: recognize and duplicate a design; recognize and extend a pattern; and locate objects in space. Results indicate that: (1) fourth graders performed better than second graders; (2) rural, white children performed better than suburban, black children with activities involving the computer; (3) rural, white girls performed better than suburban, black girls using concrete-only activities; and (4) rural, white boys using activities involving the computer performed better than suburban, black girls using concrete-only activities. These findings suggest that concrete and computer activities have different effects on children depending upon their socio-cultural background and upon their sex. (Author/JN)

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Computer Simulations and the Transition from Concrete Manipulation of Objects to Abstract Thinking

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COMPUTER SIMULATIONS AND THE TRANSITION FROM
CONCRETE MANIPULATION OF OBJECTS TO ABSTRACT THINKING

ABSTRACT

This study explores the learning model which suggests that a concept is acquired first through manipulation of concrete objects followed by transformation of the concrete objects into semi-concrete representations, followed by internalization of the concept through abstract representations.

Microcomputer simulations of manipulative activities were used to determine how children differ in their use of science-process skills and concepts when using the simulations compared to using the concrete materials, or a combination of simulations and concrete materials.

The sample for the study included a total of 113 children distributed according to male and female, 2nd and 4th grade level, and socio-cultural site. The treatment condition consisted of three levels based upon the proportion of activities using concrete objects to those using computer simulations (concrete only, concrete and computer, computer only).

The criterion measures assessed the children's ability to: recognize and duplicate a design, recognize and extend a pattern, and locate objects in space.

A multivariate analysis of variance was used to determine the influence of the computer simulations on concept development as compared to the use of concrete materials. Differential effects were tested in terms of socio-cultural background, gender, and grade level. The results indicated that:

1. Fourth graders performed better than second graders.
2. Rural, white children performed better than suburban, black children with activities involving the computer.
3. Rural, white girls performed better than suburban, black girls using concrete-only activities.
4. Rural, white boys using activities invloving the computer performed better than suburban, black girls using concrete-only activities.

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a. PURPOSE OF STUDY

Statement of the Problem

The problem in this study was to investigate the effects of combining interactive microcomputer simulations and concrete activities on the development of abstract thinking.

Objectives

Specifically, the study will assess student performance:

1. In recognition and duplication of designs,
2. In recognition and extension of patterns through seriation, and
3. In spatial orientation and discrimination tasks.

b. THEORETICAL BASIS FOR STUDY

Educators have generally accepted a theory of concept development based upon a progression from concrete objects, to representational form, and finally abstract thought. It is suggested that children acquire concepts first through concrete experiences with manipulative materials, extend their understanding of the concept by the transformation of the concrete objects into semi-concrete representations (i.e., pictures, images) and internalize the concepts through abstract thinking (i.e., symbols, letters, numbers). Several cognitive theorists support this model (e.g., Bruner, Piaget). A meta-analysis by Bredderman (1983) concluded that "...the more activity-process-based approaches to teaching science results in gains over traditional methods in a wide range of student outcome areas at all grade levels." (p. 513). The exact nature of the activity-based experience needs to be explored in terms of the materials used and their relationship to concrete and abstract thinking.

There has been much literature to support the importance of the initial, concrete manipulation of objects in the development of concepts (Dienes and Golding, 1971; Reys, 1971). The use of multiple embodiments, concepts presented in as many different ways as possible, has also been suggested (Dienes and Golding, 1971). However, the research does not provide support for the use of multiembodiments (Beardslee, 1973; Edge & Ashlock, 1982; Gau, 1973; Suydam & Riggins, 1977). Therefore, we suggest the use of mixed-mode multiembodiments or the interplay of concrete, manipulative objects and representational forms such as the computer to facilitate the development of abstract understandings. Lesh (1979) contends that the use of different modes of representation will promote meaningful learning, retention, and transfer of concepts. It is our feeling that the computer should be integrated into the curriculum as an interactive link between the concrete and abstract levels of thought.

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c. PROCEDURE OF STUDY

Subjects

The study involved 113 elementary school children (28 second grade boys; 30 second grade girls; 26 fourth grade boys; 29 fourth grade girls) randomly selected from two Ohio elementary schools. The sample represented populations from two different socio-cultural backgrounds: suburban, predominately black (N=57); rural, predominately white (N=56).

Treatment

There were three levels of the treatment condition.

a. Concrete - only activities,

b. Combination of concrete and computer simulation activities, and

c. Computer simulation - only activities.

Students within each socio-cultural site were randomly assigned by gender and grade level to the treatment conditions. The students received instruction using either pegboards and colored cubes and/or computer simulations of these materials. Students completed a total of twenty tasks designed to develop the following concepts:

a. Recognition and duplication of design

b. Recognition and extension of pattern

c. Spatial orientation and discrimination

The teachers used these activities over a three-week period in a manner determined and prescribed by the research team.

At the end of the treatment period, two paper-and-pencil instruments requiring reflective abstract thought were administered to all subjects. Test1 requires pattern recognition and is a test of the specific skills required in the concrete and computer activities. Test2 requires pattern extension and spatial orientation discrimination and is a test of the general transfer and extension of these skills. Each test consisted of six items administered to 113 subjects. The internal consistency (Cronbach's Alpha) reliabilities across all subsets of the sample were Test1 = 0.45, Test2 = 0.74. The reliabilities did not vary significantly among the various subsets of the sample based upon socio-cultural background, gender, and grade level. Scores on these instruments comprised the dependent variables.

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d. RESULTS OR CONCLUSIONS OF STUDY

The data was analyzed using four-way multivariate and univariate analyses of variance with two dependent variables. Appropriate follow-up procedures for interpretation of the results were used. For interpretation of interaction effects the means for the dependent variables were plotted and post hoc procedures employed to determine specific differences. Differences at or beyond the .10 alpha level were considered statistically significant.

Table 1
Analysis of Variance For Site, Sex, Grade Level and Treatment Significant Effects for Performance on Two Tests

SOURCE	df	MS	Multivariate		Univariate	
			F	P	F	P
Site x Sex x Treatment	4,176		1.74	.14		
Test1	2,89	.20			.16	.86
Test2	2,89	10.05			3.40	.04*
Site x Grade	2,88		10.44	.001*		
Test1	1,89	.004			.003	.96
Test2	1,89	60.27			20.38	.001*
Grade	2,88		7.68	.001*		
Test1	1,89	17.92			13.76	.001*
Test2	1,89	12.37			4.18	.04*
Site	2,88		7.62	.001*		
Test1	1,89	12.91			9.91	.002*
Test2	1,89	25.34			8.57	.004*

Table 1 reports the results of the multivariate analysis of variance and univariate analysis of variance for all significant main and interaction effects. Inspection of Table 1 reveals a significant main effect for socio-cultural site with rural-white students performing better than suburban-black students on both criterion instruments. A significant grade level effect was found with fourth grade students performing better than second grade students on both criterion instruments. A significant site by grade level interaction effect was found for only Test2. Specifically, the suburban-black, second grade boys did significantly better than their fourth grade counterparts when using the concrete-only treatment activities. In all other cases, the fourth grade students did as well as or better than second graders.

A significant three-way interaction effect involving site by sex by treatment was found only for Test2. The Scheffé post hoc tests revealed the following differences:

a. Rural - white girls performed significantly better than suburban - black girls when using concrete-only activities.

b. Rural - white boys performed significantly better than suburban - black girls when using either concrete-computer activities or computer-only activities.

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e. IMPLICATIONS FOR TEACHING SCIENCE

The influence that concrete manipulation of objects and computer activities have on the students' transition from concrete understanding to abstract thinking is not clear at this point. The evidence from this study suggests that not all students are influenced in the same manner. In this study when concrete-only activities were used, the white girls from the rural environment did much better in acquiring science-process skills and concepts than did the suburban-black girls. When the computer was incorporated into the learning activities there was a tendency for these two populations to become more alike in their understanding. The inclusion of computer activities as compared to concrete-only activities tends to lower the scores of rural-white girls while raising the scores of suburban-black girls.

There is also some evidence that the sex of the student has some relationship to the effect of the learning activity. The suburban-black female students using the concrete materials generally scored lower than all other groups on the criterion measures. The rural-white boys using a combination of the concrete and computer activities or the computer-only activities demonstrated a significantly higher level of skill and concept understanding than the suburban-black girls with concrete-only activities.

The nature of the effect of concrete and computer activities in the learning of science-process skills and concepts is in need of a great deal more investigation. It appears from the significant findings and from the trends reported in this study that boys and girls react differently to the use of concrete objects and computer activities. In fact, the effects of the treatments in this study for suburban-black boys looks very much the same as the effects on rural-white girls. Also, the pattern of effects for suburban-black girls looks much the same as the pattern for rural-white boys.

At this point it can be stated that the concrete and computer activities have different effects on children depending upon their socio-cultural background and upon their gender. The nature of those effects is not yet clear but teachers and curriculum designers should be aware of and stay alert for signs of positive and negative influences upon children's progress in learning. In the classroom, this study might suggest an environment which provides concrete, manipulative representations such as colored cubes, pegboards, attribute blocks, and pattern cards along with computer simulations of these activities. Children should be encouraged to choose from these different modes or to combine different modes of representation. The amount of time spent in each mode should be monitored so that students remain actively engaged in the task.

Further research should be done to help delineate the nature of the differential influences of concrete and computer activities specific to children with different characteristics. The first step should be replication of this study with more subjects, more potent treatments, and the use of the activities over a longer period of time. There is also a need for refinement and improvement of the criterion measures so as to have more sensitive, reliable, and valid estimates of students' concepts and skills.

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